Application No.: 10/540,618 Docket No.: FHW-142US

AMENDMENTS TO THE DRAWINGS

The attached sheet of drawings includes changes to Fig. 1. This sheet, which includes Fig. 1, replaces the original sheet including Fig. 1. Applicants add a "Prior Art" legend to Fig. 1, and request the Examiner to reconsider and withdraw the objection to the drawings.

Attachment: Replacement sheet
Annotated sheet showing changes

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REMARKS

Applicants amend claim 1 and cancel claim 7. Claims 1-6 and 8-22 are pending, of which claim 1 is independent. No new matter has been introduced. Applicants respectfully submit that the pending claims define over the art of record.

Information Disclosure Statement

The Examiner asserts that the information disclosure statement filed 23 June 2005 fails to comply with 37 CFR 1.98(a)(2) on grounds of illegibility. Applicants attach a legible copy of each non-patent literature publication as submitted in the information disclosure statement, and respectfully request the Examiner to reconsider and withdraw the objection to the information disclosure statement.

Objection to the Drawings

The Examiner asserts that Figure 1 should be designated by a legend such as "Prior Art." Applicants comply with the recommendation and attach amendments to the drawings. Applicants respectfully request the Examiner to reconsider and withdraw the objection to Figure 1.

The Examiner further asserts that the drawings are objected to because they include reference characters not mentioned in the description. Applicants amend the specification to include mentions of the reference characters in the drawings. In light of the foregoing amendments to the specification, Applicants respectfully request the Examiner to reconsider and withdraw the objection to the specification.

Claim Objections

Claims 14 and 15 are objected to because of informalities. The Examiner asserts that claims 14 and 15 are "improper because the parent claim states that there can be just semiconductor or just dielectric." See office action, paragraph 4. Applicants amend claims 13, 14 and 15 to address the Examiner's concerns.

Claim 13 states: "A coupler according to claim 12, the layered structure comprises one or more layers of semiconductor material, or dielectric material, **or both**." However, the parent

claim 13 does **not** state that there can be just semiconductor or just dielectric. Rather, claim 13 limits the layered structure in the coupler in claim 12, so that the layered structure includes semiconductor material **and/or** dielectric material. Claim 14 further limits the semiconductor material in claim 13 to include one or more of specific semiconductor materials. Claim 15, on the other hand, further limits the dielectric material in claim 13 to glass. Based on the foregoing claim amendments and the assertions of claims 13, 14 and 15, Applicants respectfully submit that the further limitations of claims 14 and 15 are not improper in view of parent claim 13.

The Claimed Invention

The present invention is generally directed to an optical coupler that comprises an input waveguide, an intermediate waveguide, an output waveguide, a first grating situated between the input and intermediate waveguides, and a second grating situated between the intermediate and output waveguides such that, in use, light propagating in the input waveguide is coupled into the intermediate waveguide with the assistance of the first grating, and thence is coupled into the output waveguide with the assistance of the second grating. See abstract. The intermediate waveguide has a higher refractive index than the input waveguide and a lower refractive index than the output waveguide. See page 7, lines 13-16. The coupler is a directional coupler, in particular a dual grating-assisted directional coupler, and may be used to couple light between an optical fiber and an integrated semiconductor device, or between dissimilar waveguides. See abstract.

The invention has the advantage that the use of two gratings and the intermediate waveguide enables high coupling efficiency between the input and the output waveguides, which preferably have differing geometries and/or refractive indices. See page 3, lines 31-34. The use of the intermediate waveguide layer enables highly efficient coupling to occur at both gratings, consequently forming an efficient Dual Grating-Assisted Directional Coupler (DGADC). See page 7, lines 16-19.

Rejection of Claims 1-6, 8-18 and 20-22 under 35 U.S.C. §102

The Shibata Reference

Claims 1-6, 8-17 and 22 are rejected under 35 U.S.C. §102(b) as being anticipated by United States Patent No. 5,444,802 to Shibata et al. ("Shibata"). Applicants respectfully submit that the Shibata reference does not disclose "an input waveguide, an intermediate waveguide, an output waveguide" or "the intermediate waveguide has a higher refractive index than the input waveguide and a lower refractive index than the output waveguide," as required by amended independent claim 1.

The Shibata reference is generally directed to optical switches to be used in communication systems based on the propagation of light within waveguides, and especially relates to an optically-controlled grating optical switch in which an ON-OFF of signal light is controlled by a control light. See Shibata, column 1, lines 9-14.

Applicants respectfully submit that the Shibata reference fails to disclose "an input waveguide, an intermediate waveguide, an output waveguide," as required by claim 1. In the first embodiment of the Shibata reference (Figure 7-8, 14, 17), the Examiner points to 14a or 14b as being an input waveguide, 14c as being an intermediate waveguide, and 14d as being an output waveguide. Applicants contend that the features pointed out by the Examiner in the Shibata reference do not disclose an input waveguide, an intermediate waveguide and an output waveguide. The Shibata reference states: "The optical waveguide for signal light 17 has input/output optical wave guide regions 14a and 14b on both ends thereof, respectively and between the two ends several different regions are formed: a grating switch region 13 for switching transmission and reflection of the signal light; input/output optical waveguide regions 14b and 14c." See Shibata, column 6, lines 16-22. The first embodiment of the Shibata invention discusses the function of enabling or disabling propagation through the same optical waveguide. 14a and 14b of the first embodiment are input/output regions of the same waveguide. 14b and 14c are input/output optical waveguide regions located between the ends of the same optical waveguide for signal light 17. Thus, the first embodiment of the Shibata reference fails to disclose three waveguides, namely, an input waveguide, an intermediate waveguide and an output waveguide, as required by claim 1.

In the second embodiment of the Shibata reference (Figure 10, 13, 17), the Examiner points to 18 as being an input waveguide, 14 as being an intermediate waveguide, and "not labeled, the mirror of 18" as being an output waveguide. Applicants contend that the features pointed out by the Examiner in the Shibata reference do not disclose an input waveguide, an intermediate waveguide and an output waveguide. The Shibata reference states: "In a second aspect of the present invention, an optical switch for ON-OFF switch control of a signal light transmission and a signal light reflection by means of control light, comprises:... a first optical waveguide for guiding the signal light and formed on the substrate... a second optical waveguide for guiding control light and formed on the substrate, a part of the second optical waveguide being close to the first optical waveguide to form a directional coupler for coupling the control light colinearly to the signal light and for guiding the control light to the grating together with the signal light." See Shibata, column 4, line 55 – column 5, line 5. The Shibata reference discloses the two aforementioned waveguides: a waveguide for guiding the signal light and a waveguide for guiding the control light. The Shibata reference does not disclose a third intermediate waveguide, as required by claim 1 of the current application. Applicants respectfully request the Examiner to furnish specific mention of "the mirror of 18" (i.e. an intermediate waveguide) in the Shibata reference. In addition, the Shibata reference does not disclose that the aforementioned waveguides are input and output waveguides. Thus, the second embodiment of the Shibata reference also fails to disclose an input waveguide, an intermediate waveguide and an output waveguide, as required by claim 1. In light of the foregoing arguments, Applicants respectfully submit that the Shibata reference does not disclose "an input waveguide, an intermediate waveguide, an output waveguide," as required by claim 1.

Applicants also respectfully submit that the Shibata reference fails to disclose that "the intermediate waveguide has a higher refractive index than the input waveguide and a lower refractive index than the output waveguide," as required by claim 1. The Shibata reference does not discuss the subject matter of the refractive index of an intermediate waveguide that lies between an input waveguide and an output waveguide. The Shibata reference is silent and hece does not teach an intermediate waveguide having a higher refractive index than the input waveguide and a lower refractive index than the output waveguide.

In light of the foregoing arguments, Applicants respectfully submit that the Shibata reference does not disclose each and every element of independent claim 1. Applicants respectfully request that the 35 U.S.C. 102(b) rejection of claim 1 in view of the Shibata reference be withdrawn. Reconsideration and allowance of claim 1 is requested in view of the above remarks.

Claims 2-6, 8-17 and 22 depend upon claim 1 and add separate and patentable limitations to claim 1. As such, for this and the reasons set forth above, Applicants respectfully submit that the dependent claims also define over the art of record.

The Handa Reference

Claims 1, 5-6, 8, 11, 16-18 and 20-21 are rejected under 35 U.S.C. §102(b) as being anticipated by United States Patent No. 4,776,661 to Handa ("Handa"). Applicants respectfully submit that the Handa reference does not disclose that "the intermediate waveguide has a higher refractive index than the input waveguide and a lower refractive index than the output waveguide," as required by independent claim 1.

The Handa reference is generally directed to an integrated optical device which is both compact and capable of inputting and outputting a beam of light with a high level of efficiency. The aforementioned object of the present invention is attained by providing, in accordance with one aspect of the invention, an integrated optical device comprising a substrate, a slab optical waveguide provided on the substrate, a channel optical waveguide provided at a portion of the slab optical waveguide, and a grating coupler provided with a grating structure at a portion of the channel optical waveguide and adapted to optically couple the slab optical waveguide and the channel optical waveguide. See Handa, column 3, lines 29-41.

Applicants respectfully submit that the Handa reference fails to disclose that "the intermediate waveguide has a higher refractive index than the input waveguide and a lower refractive index than the output waveguide," as required by claim 1. The Handa reference is silent about the relative refractive indices of its constituent waveguides. The Handa reference states: "For instance, as a channel optical waveguide, it is possible to employ, instead of the above-described rib type waveguide, an embedded type waveguide in which a layer 71 having a

higher refractive index than the slab waveguide 4 is embedded in the slab waveguide." See Handa, column 14, lines 4-9. The Handa reference discusses that the refractive index of the rib type waveguide can be higher than the slab waveguide, but it fails to disclose the relative refractive index of an intermediate waveguide with respect to the refractive indices of an input waveguide and an output waveguide, as required by claim 1.

In light of the foregoing arguments, Applicants respectfully submit that the Handa reference does not disclose each and every element of independent claim 1. Applicants respectfully request that the 35 U.S.C. 102(b) rejection of claim 1 in view of the Shibata reference be withdrawn. Reconsideration and allowance of claim 1 is requested in view of the above remarks.

Claims 5-6, 8, 11, 16-18 and 20-21 depend upon claim 1 and add separate and patentable limitations to claim 1. As such, for this and the reasons set forth above, Applicants respectfully submit that the dependent claims also define over the art of record.

Rejection of Claims 7 and 19 under 35 U.S.C. §103

The Shibata Reference

Claim 7 is rejected under 35 U.S.C. §103(a) as being unpatentable over Shibata. Applicants respectfully submit that the rejection of claim 7 is moot in view of the cancellation of claim 7 in the foregoing claim amendments. Applicants address the Examiner's rejection of claim 7 in view of base claim 1 as set forth below.

Based on the foregoing arguments, Applicants respectfully submit that the Shibata reference does not teach or suggest "an input waveguide, an intermediate waveguide, an output waveguide" or "the intermediate waveguide has a higher refractive index than the input waveguide and a lower refractive index than the output waveguide," as required by independent claim 1.

With regard to the Shibata reference, the Examiner states: "At the time of the invention, it would have been obvious to a person of ordinary skill in the art to create any needed refractive index difference boundary between waveguides to promote coupling as taught by Shibata

including the relationship claimed. Applicant has not disclosed that this exact relationship provides an advantage, is used for a particular purpose, or solves a stated problem and therefore lacks criticality." See office action, paragraph 7. Applicants respectfully disagree for the reasons set forth below.

Applicants respectfully submit that the aforementioned claim 1 limitation provides for certain advantages. The current application states: "The invention has the advantage that the use of two gratings and the intermediate waveguide enables high coupling efficiency between the input and the output waveguides, which preferably have differing geometries and/or refractive indices." See page 3, lines 31-34. The application further states: "The refractive index of intermediate waveguide layer generally must be larger than that of input waveguide layer, but less than the refractive index of the output waveguide layer. The intermediate waveguide layer is crucial for the operation of the coupler device, because it enables highly efficient coupling occurring at both gratings, consequently forming an efficient Dual Grating-Assisted Directional Coupler (DGADC)." See page 7, lines 13-19. Thus, the application discloses the relative refractive index of the intermediate waveguide with respect to that of the input and output waveguides, and discusses that the intermediate layer is crucial in enabling highly efficient coupling between the input and output waveguides. Thus, Applicants have disclosed in the current application that claim 1 limitation "the intermediate waveguide has a higher refractive index than the input waveguide and a lower refractive index than the output waveguide" has a particular purpose and confers certain advantages on the claimed invention.

In view of the foregoing arguments, the Shibata reference does not teach or suggest an intermediate waveguide, and provides no implicit teaching for an intermediate waveguide or the relative refractive indices of the waveguides, as required by claim 1. The Shibata reference does not teach or suggest that the "input", "intermediate" and "output" portions of the optical waveguide for signal 17 have different refractive indices. There is no motivation for a person of ordinary skill in the art to modify the disclosed invention in the Shibata reference to incorporate an input waveguide, an intermediate waveguide and an output waveguide. In addition, there is no motivation for a person of ordinary skill in the art to vary the refractive indices of the different portions of the optical waveguide in the Shibata invention in accordance with claim 1

limitation "the intermediate waveguide has a higher refractive index than the input waveguide and a lower refractive index than the output waveguide."

In light of the foregoing arguments, Applicants respectfully submit that the Shibata reference does not teach or suggest each and every element of independent claim 1.

The Sakata Reference

Claim 19 is rejected under 35 U.S.C. §103(a) as being unpatentable over Shibata in view of United States Patent No. 5,140,149 to Sakata et al. ("Sakata"). Claim 19 is dependent upon base claim 1. In view of the foregoing arguments, Applicants respectfully submit that the Shibata reference does not teach or suggest "an input waveguide, an intermediate waveguide, an output waveguide" or "the intermediate waveguide has a higher refractive index than the input waveguide and a lower refractive index than the output waveguide," as required by independent claim 1. The addition of the Sakata reference fails to cure this deficiency. Applicants respectfully submit that the Sakata reference also fails to teach or suggest "an input waveguide, an intermediate waveguide, an output waveguide" and "the intermediate waveguide has a higher refractive index than the input waveguide and a lower refractive index than the output waveguide," as required by claim 1.

The Sakata reference is generally directed to an optical apparatus such as a photosensor, a semiconductor laser, an optical amplifier in which a wavelength selective photocoupler is used so as to couple two waveguides through a diffraction grating. A photosensor which is one of the optical apparatus according to the present invention comprises a substrate, a first waveguide layer formed on the substrate, a second waveguide layer formed on the first waveguide layer to be stacked in a direction of thickness and which has a guided mode difference from that of the first waveguide layer, a diffraction grating formed on an overlapping region of the guided modes of the first and second waveguide layers and which couples light components of a specific wavelength range of light propagating through the first waveguide layer to the second waveguide layer. See Sakata, abstract.

Applicants respectfully submit that the Sakata reference fails to teach or suggest "an input waveguide, an intermediate waveguide, an output waveguide," as required by claim 1. The

Sakata reference discusses a first and a second waveguide layer, but does not teach or suggest an intermediate waveguide layer. Applicants further submit that the Sakata reference does not teach or suggest "the intermediate waveguide has a higher refractive index than the input waveguide and a lower refractive index than the output waveguide," as required by claim 1. The Sakata reference provides no teaching about the relative refractive index of an intermediate waveguide with respect to the refractive indices of an input waveguide and an output waveguide. Thus, Applicants submit that the Sakata reference, even if combined with the Shibata reference, fails to motivate the aforementioned limitations of claim 1.

In light of the foregoing arguments, Applicants respectfully submit that the Shibata reference and the Sakata reference, alone or in combination, do not teach or suggest each and every element of independent claim 1.

Claim 19 depends upon claim 1 and adds separate and patentable limitations to claim 1. As such, for this and the reasons set forth above, Applicants respectfully request that the 35 U.S.C. 103(a) rejection of claim 19 in view of the Shibata and Sakata references be withdrawn. Reconsideration and allowance of claim 19 is requested in view of the above remarks.

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CONCLUSION

In view of the above amendment, Applicants believe the pending application is in condition for allowance.

A petition for a two-month extension and the requisite fee is submitted herewith. Applicants believe that no additional fee is due with this statement. Please charge our Deposit Account No. 12-0080, under Order No. FHW-142US from which the undersigned is authorized to draw. If the requisite petition does not accompany this response, the undersigned hereby petitions under 37 C.F.R. §1.136(a) for an extension of time for as many months as are required to render this submission timely. Any fee due is authorized to be charged to the aforementioned Deposit Account.

Dated: December 5, 2006

Respectfully submitted,

By ______________________

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Attachments

App No.: 10/540,618
Inventor: Graham REED et al.
Title: OPTICAL COUPLER
ANNOTATED SHEET

Docket No.: FHW-142US

1/7

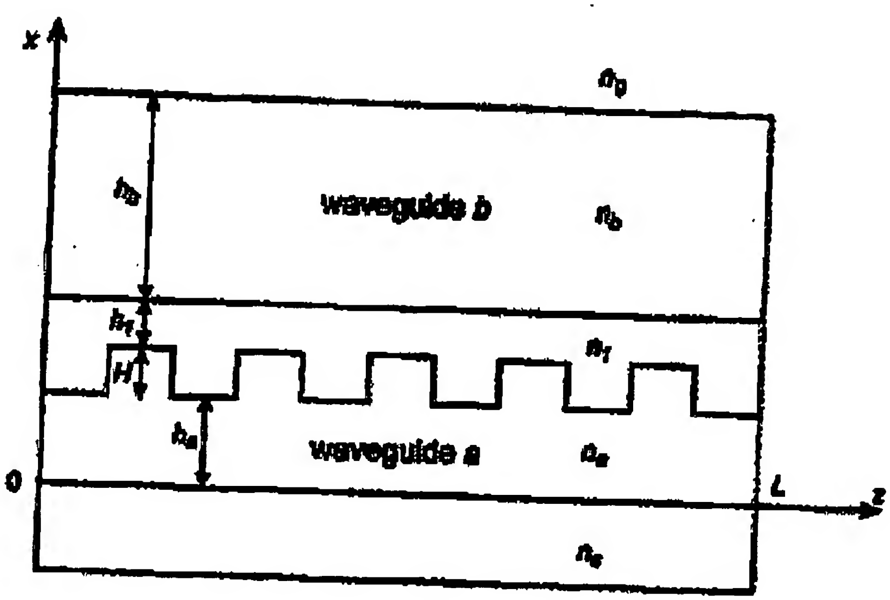

Figure 1.

(Prior Art)

Fiber Bragg Gratings

Raman Kashyap
BT Laboratories, Martlesham Heath
Ipswich, United Kingdom

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The cover picture shows the near-field photographs of radiation mode patterns of several low-order counterpropagating modes (LP_{0n}). These are excited by the forward propagating core mode in a 6-mm-long, side-tap grating with a 2° blaze angle, written into the core of a single mode fiber. *Artwork by Arjun Kashyap.*

This book is printed on acid-free paper. ∞

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A PBS-OADM has been demonstrated for a single channel using seven wavelengths spaced at 0.8-nm intervals. The center channel was dropped with a cross-talk penalty of 0.3 dB when the same wavelength was added at a transmission rate of 2.5 Gb/sec. Heating part of one arm of the PBS-OADM by 65°C induced a change of 0.3 dB at the output [73]. However, it remains to be seen how this device will function under full environmental testing. Figure 6.40 shows a schematic of the PBS-OADM [73].

6.7 In-coupler Bragg grating filters

Co- and contradirectional wavelength selective couplers have been known for a long time [74,75]. There are a number of ways that gratings in-couplers may be used to form band-pass filters. Figure 6.41 shows three different types of couplers, which include gratings to assist (grating-assisted coupler, GAC), to frustrate (grating-frustrated coupler, GFC) and to reflect (Bragg reflection coupler, BRC) light of a particular wavelength that meets the phase-matching requirements.

The period of the refractive index-perturbation for codirectional grating-assisted coupling [GAC, Fig. 6.41 (*i*)] between two dissimilar fibers is determined by the difference in the propagation constants of the two guides. This is generally small, and therefore the period is long. For weak overlap of the fields, the coupled-mode equations (see Chapter 4 on long-period gratings), describe the interaction between the modes. The coupling between the guides is sinusoidally periodic with length of the grating-assisted region. The coupling has a relatively broad bandwidth (tens of nanometers) and therefore poor wavelength selectivity, unless the device can be made very long.

A normally 100% coupler is strongly detuned by the dispersion of the grating and so fails to behave as a coupler near the Bragg wavelength, and is called a grating-frustrated coupler [GFC, Fig. 6.41 (*ii*)]. It works on the following principle: Two fibers with identical propagation constants will exchange power at all except the "grating-frustrated" wavelength. The in-fiber grating is a Bragg reflector at the frustrated-wavelength and is present in only one of the fibers. The far end of the input fiber becomes the "drop" port and is the one that does not contain the grating.

The Bragg reflecting coupler [BRC, Fig. 6.41 (*iii*) and (*iv*)] requires a perturbation with a short period, as is the case for Bragg reflection, being dependent on the sum of the magnitudes of propagation constants of

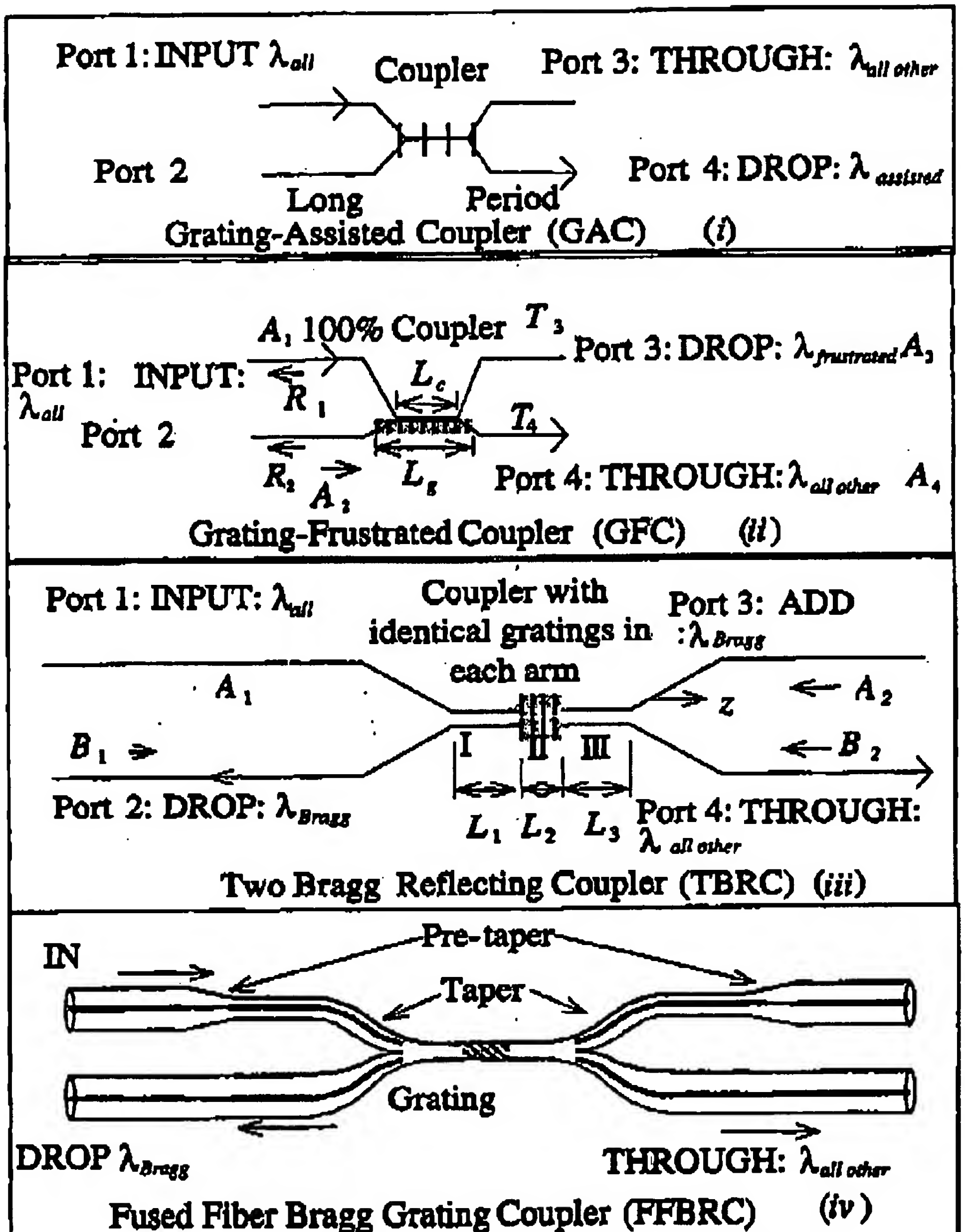

Figure 6.41: Some examples of band-pass filters with in-coupler gratings.

the two modes. This device can made with either two gratings in polished couplers [76,77] or a single one written into a fused coupler [78], since the perturbation has to be present in the entire cross-section of the coupling region. The dropped channel is reflected and routed to port 2 of the fiber coupler. In the following sections, the characteristics of the latter two devices are presented.

6.7.1 Bragg reflecting coupler OADM

The BRC-OADM [76–78] is probably the most promising of all the OADM devices that rely on interference. Essentially, this is a new twist to a range of generic devices based on the grating-assisted coupling action. Apart from being a simple device and having very low insertion loss, the BRC has the potential of fulfilling the requirements for a high extinction at the "dropped" as well as the "through" ports, and low back-reflection into the input port. Schematics of the BRC in the assembled and fused forms are shown in Fig. 6.41 (iii, iv). In its fused form, it comprises two fibers tapered down to form a long coupling region in which the fibers are kept parallel, followed by a short grating and another long coupling region before the fibers separate.

The principle of operation is probably the cleanest of all the different types of grating couplers and may be understood in the following phenomenological way: The light input into port 1 propagates adiabatically in the tapered region to excite the supermodes of the coupler. In this region, the two fibers merge into a single strand and become a glass rod without a core, surrounded by air. In a normal coupler without the grating, 100% of the light is transferred from one set of modes to the other to exit at port 4. If, however, a point reflector is placed at exactly half the coupling length, then the divided power between the modes travels backward toward ports 1 and 2, and the coupling process continues uninterrupted, apart from the π phase change induced by the reflection in all the supermodes. Thus, instead of propagation in the positive z-direction, the supermodes travel in the negative z-direction and interfere at the exit of the coupler and are routed by symmetry into port 2. In the BRC, the Bragg grating replaces the point reflector, which is wavelength selective, and routes light only near the bandgap into port 2. This simple picture is surprisingly accurate, despite the fact that coupling continues within the grating region, due to light penetration. It is immediately apparent that a strong grating would be preferable, although complications arise since the presence of the grating detunes the coupling action. The BRC can also be considered to be a close analog to the